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ABSTRACT

Two experiments were conducted (1) to identify the component processes of language comprehension that draw upon cognitive capacity for their execution, and (2) to determine differences in patterns of resource allocation during integrative processing for good and poor readers. In the first experiment, nine good and nine poor college-age readers performed two tasks. The primary task was to listen to a text for comprehension, while the second was to watch a screen on which numbers would be projected. When a number appeared, each subject determined whether it was odd or even and responded as rapidly as possible by pushing the appropriate button. In the second experiment, nine good and nine poor college-age readers were seated at a CRT terminal and told that they would be presented with a story, one word at a time, and that after they had read a word of the story they were to press a button and the next word would appear. Results indicated that when reading, good readers were more likely than poor readers to engage in effortful processing. However, the results indicated that when listening, both good and poor readers attempted inferential coherence. The findings suggest that texts requiring inferences (lacking conceptual coherence) were more resource demanding. (FL)

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The Use of Attention in Reading and Listening: Do Good and Poor Readers Differ?

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Abstract

Two experiments investigated the hypothesis derived from the Kintsch and van Dijk (1978) model of text comprehension that two integrative processes in reading (reinstatement searches and inference-making) are resource demanding. Good and poor reader differences were also explored with respect to integrative processing. In Experiment 1, reaction times to respond to secondary task probes were slower on reinstatement cycles than control cycles. In Experiment 2, using a SPVP paradigm, good readers spent more time than poor readers at those points in the text predicted to require an inference, reinstatement, or sentence wrap-up.

Comprehension is generally considered to be a complex task which combines several interacting systems that differentially draw upon limited capacity processing resources. For proficient readers, at least some of the components of reading such as word recognition are assumed to be relatively automatic while others such as drawing inferences to link propositions are assumed to be heavily resource demanding. Knowing how different components of discourse processing draw on processing resources is an important goal for understanding cognitive processes underlying skilled and less skilled reading (Carr, 1981; LaBerge & Samuels, 1974; Stanovich & West, 1981).

The most explicit claims of resource demands during text comprehension are made by Kintsch and his colleagues (e.g. Kintsch & Vipond, 1977; Kintsch & van Dijk, 1978). In this model comprehension is assumed to involve a complex set of processes which are highly interactive and operate in parallel. In comprehending a text, the language-understander must construct a coherent representation of its meaning. A text base must be coherent in order to be comprehended and must be checked for referential coherence (the overlap of arguments among propositions).

However, a lack of referential coherence triggers additional processes which are resource-demanding. First, if no argument overlap is found, a search of all previously processed propositions in long-term memory is conducted (reinstatement

search). Secondly, if the reinstatement search fails, inference-making is initiated to add propositions that will provide the necessary coherence to the text base. Since inference-making occurs only if a reinstatement search fails, inference-making should require more resources than reinstatement searches.

In the present study, a dual-task paradigm was used to explore the capacity requirements of inference-making and reinstatement searches. In the dual-task paradigm, subjects are asked to perform two tasks simultaneously. They are instructed to devote enough attention to the primary task to perform it well, using whatever resources are left over to perform the secondary task (even if it means performance on the secondary task when performed alone to performance in the dual task condition, it is possible to observe the pattern of resource requirements for the primary task. The primary task was listening to texts for good comprehension. The secondary task was responding "even" or "odd" to visually presented numerals. Further, since readers of varying skill levels may differ with respect to the execution of one or both of these integrative processes, readers of varying skill levels were used.

Experiment 1

Method

Subjects. Nine good readers and nine poor readers were selected from a group of introductory psychology students at the University of Colorado on the basis of reading scores on the

Nelson-Denny. The mean score of the good readers corresponded to the 84th percentile and the mean score of the poor readers corresponded to the 18th percentile.

Materials. Nine short paragraphs each of which had been extracted from a longer text and adapted from Reader's Digest articles were used. Further, the paragraphs had been propositionalized by Kintsch and his colleagues and submitted to a simulation of the. Kintsch and van Dijk (1978) model. The simulation specified points in each paragraph where a reinstatement search or inference was to occur according to model predictions based on the "leading edge strategy."

Order of paragraph presentation across conditions was counterbalanced using a 9 x 9 Latin square, replicated in each level of reading ability. One text was presented in the Primary Task only condition, seven texts were presented in the Dual Task condition. Twelve "filler" texts were also used in the experiment. Five true/false comprehension questions about each of the twenty-one paragraphs were constructed. Multiple slides containing the numerals between 1 and 8, inclusively, were prepared. Four numerals were presented during each text; however, all "critical" probes were odd. Distribution of the four probes within a typical paragraph is illustrated in Table 1.

Insert Table 1 about here

Tasks

Subjects performed two tasks in the experimental conditions. The primary task was to listened to each text for comprehension. The secondary task was to watch a screen in front of them on which numerals would be projected. When a numeral appeared, a subject was to determine whether it represented an even or odd number and respond as rapidly as possible by pushing one of two buttons (one labeled "even" or one labeled "odd").

Procedure

After the primary task was explained, subjects listened to one practice text and answered the corresponding comprehension questions. Next, the secondary task was introduced and subjects responded to thirty (30) trials on which visual probes (15 even and 15 odd) were presented in a random order. This sequence constituted the first half of the "secondary task alone" condition. Subjects then practiced on three texts again taking the corresponding comprehension test. If they had no questions about the procedure at this point, the remaining 17 texts (9 critical texts and 8 fillers) were presented in the dual task condition with their comprehension tests. Finally, subjects responded to 30 trials of the secondary task alone (constituting the second half of that condition).

Results and Discussion

The assumption that changes in reaction times to probes in the dual task condition reflected increases in resource demands is

valid only if enough resources were allocated to listening to comprehend the text. This was tested by submitting comprehension scores to an analysis of variance including the variables of Reading Ability (Good, Poor) and Comprehension Condition (Dual Task, Primary Task Only). Comprehension under dual task conditions was not significantly different from comprehension while only listening, $F < 1.0$ validating the assumptions of the paradigm.

Mean reaction times for each type of comprehension cycle and its corresponding control are presented for each level of reader ability in Table 2. Since the text were "natural," there were asymmetries in the types of observations obtained from each of

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Insert Table 2 about here

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them. Therefore, separate ANOVAs were performed on those texts requiring reinstatement searches and on those texts requiring inferences. Each analysis included the between-subjects variable of Reading Ability (Good, Poor) and of Type of Comprehension Cycle (Reinstatement vs. Control or Inference vs. Control).

The analysis of reinstatement search cycles revealed only a main effect of Comprehension Cycle, $F(1, 16) = 4.91$, $p < .05$. Mean reaction time during reinstatement cycles was 842 msec versus 659 msec during control cycles. Thus, the decrement in secondary task performance due to increased resource demands of

reinstatement searches was 183 msec. In the analysis of texts requiring inferences, the only effect to approach significance was the main effect of Type of Comprehension Cycle, $F(1, 16) = 3.80$, $p < .07$.

The insignificant effect obtained for inference-making in the second analysis could merely be due to the fact that RTs to these control probes were relatively longer. Response latency to visual probes on these texts may have been slowed more because these texts were less cohesive than the first set, since many of them lacked referential coherence (hence, requiring a reinstatement search) as well as lacking conceptual coherence (thus requiring an inference). This lack of cohesion might tax a listener's capacity more heavily throughout all cycles of comprehension than texts lacking only referential cohesion. However, the dual task paradigm only provides brief "snapshots" of time within the text whereas other paradigms such as the SPVP paradigm provides a more continuous record of effort over time more akin to a "film."

Therefore, in Experiment 2, the same texts were used again with good and poor readers in a self-paced visual presentation paradigm in order to obtain a more continuous record of effort during discourse comprehension. In addition, since the ends of the sentences and the ends of idea units may also be considered points of integration (cf. Carpenter & Just, 1977), these points in the text were also considered.

Experiment 2

Method

Subjects. Nine good and nine poor readers were selected from the Wayne State University Community according to similar criteria as in Experiment 1.

Texts for Comprehension. The same nine texts used in the first experiment were used in Experiment 2.

Order of paragraph presentation across conditions was counter-balanced using a 9 x 9 Latin square, replicated in each level of reading ability.

Procedure. Each subject was seated at a CRT terminal and the experimenter began the program that presented each story. The instructions informed the subject that he/she would be presented with a story one word at a time and that after they had read a word of the story they were to press a button and the next word would appear. When they were ready to begin, they were instructed to push the button. Each subject then read each of the nine paragraphs.

Results and Discussion

Of the eighteen subjects on which data were collected, the data from one good reader were lost during a system crash. In order to facilitate the analysis, the data from one poor reader, chosen at random, were eliminated. This left 16 subjects, eight good readers and eight poor readers, who contributed data toward the analysis.

Recall that subjects read each of nine paragraphs word-by-word and reading time per word (in msec) was recorded. Since the computer began timing when the instructions to display the next word were executed, the time to display each word on the CRT was subtracted from each raw reading time. The corrected reading times were then standardized paragraph by paragraph using each paragraph's mean and standard deviation across all 16 subjects.

Only words terminating a comprehension cycle were retained for analysis. In addition, five "control" words were randomly selected from the remaining words in each paragraph (where no resource-demanding activity was predicted). Reinstatement texts and Inference texts were considered separately for purposes of analysis for reasons given before. The means for these two sets of texts are presented in Table 3. As can be seen from the table

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Insert Table 3 about here

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inferences, reinstatements, and sentence wrap-ups take substantially longer than idea wrap-ups or controls.

These means were submitted to analyses of variance. Analyses for both sets of texts included the factors of Reading Ability, Paragraph, and Comprehension Cycle. The analysis revealed a main effect of Paragraph for the inference texts, $\underline{F}(6, 84) = 2.33$, $\underline{p} < .05$, suggesting that inference texts varied considerably in the amount of resources they demanded. The main effect of Cycle was

highly significant for both sets of texts, $F(3, 42) = 17.89$, $p < .01$, for inference texts; and $F(3, 42) = 51.06$, $p < .01$, for reinstatement texts. More mental effort was spent on sentence wrap-ups, reinstatements, and inferences than elsewhere in the text. This is consistent with what current theories suggest. Of central importance in the analysis under discussion now was the fact that the main effect of Cycle was modified by an interaction with Reading Ability on both sets of texts, $F(3, 42) = 3.49$ $p < .05$, for inference texts; and $F(3, 42) = 5.06$, $p < .05$ for reinstatement texts.

Considering first the inference texts, good readers spent more than twice the time on sentence wrap-ups than poor readers did. Similarly, they spent much more time on inference-making. However, regardless of reading ability, sentence wrap-ups and inference-making required more effortful processing than did idea wrap-ups or controls. The results for the reinstatement texts were almost identical to these. Good readers spent twice as much time on sentence wrap-ups and reinstatement searches as poor readers did. The groups differed minimally on idea wrap-ups and control cycles.

The interaction of Cycle and Paragraph also reached significance on the inference texts, $F(18, 252) = 3.93$, $p < .05$ only. The effects for type of comprehension cycle did not replicate across all nine paragraphs.

While the major predictions were confirmed, several comments

need to be made with respect to the inference texts. Contrary to expectation, more effort appeared to be devoted to reinstatements than to inferences (.81 versus .31). According to Kintsch and van Dijk (1978), inferences should require more time than reinstatement searches since they occur only when a reinstatement search fails to find an overlapping proposition in long-term memory. The result could merely be an artifact of averaging if inferences are quite often not made. In this case, we would be averaging over multiple instances of reinstatement search failure which are not then followed by an inference-making procedure. Additional evidence that inferences are not always drawn comes from the failure to replicate the type of comprehension cycle effect across all nine of the inference paragraphs.

General Discussion

The major purposes of the two experiments reported here were to identify two component processes of language comprehension that drew on cognitive capacity for their execution and to determine differences in patterns of resource allocation during integrative processing for good and poor readers. There were three more specific predictions tested in the experiments.

The first prediction was derived from the Kintsch and van Dijk (1978) model of text processing. In this model text processing proceeds in a cyclical fashion. Propositions are input into a memory buffer and checked for referential coherence (overlap of arguments between the input propositions and those in

long term memory). When a referential coherence check fails, there is a search of all propositions in long-term memory (reinstatement search). If the memory search is successful, the argument is reinstated in the memory buffer. However, if the long-term memory search is unsuccessful, then an inference-making routine is initiated in order to add the necessary arguments to make the representation coherent. The first prediction then was that reinstatement searches and inference-making are resource-demanding integrative processes in language comprehension. In addition, considering these two processes, inference-making was predicted to be more resource-demanding than reinstatement searches.

The third prediction tested was that good readers would be more likely than poor readers to execute these integrative processes. Since inference-making was predicted to draw most heavily on resources and to be the more complex of the two integrative processes, then good readers would be more likely to make inferences. Therefore, we expected that the effect of type of comprehension process would be qualified by Reading Ability.

In Experiment 1, response times to visually presented probes at points in a text where reinstatement searches but not inferences were predicted to occur were slowed. In Experiment 2, the prediction of points in a text requiring attentional resources was extended to sentence and idea wrap-ups. With respect to this prediction, more mental effort was spent on sentence wrap-ups,

reinstatements, and inferences than elsewhere in the text. Contrary to expectation, more effort appeared to be devoted to reinstatements than to inferences (.81 versus .31). In Experiment 2, good readers were much more likely than poor readers to engage in effortful processing at points in a text requiring sentence wrap-ups, reinstatement searches, and inference-making.

In summary, it appears that when reading, good readers are more likely than poor readers to engage in effortful processing. However, when listening it appears that both good and poor readers attempt referential coherence. In both experiments, it was not clear that inferences are always drawn. It was clear that texts requiring inferences (lacking conceptual coherence) were more resource demanding. More research is needed to determine the factors governing when inferences will be made and to determine differences between good and poor readers on this integrative process.

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Table 1

Distribution of the Four Secondary Task Probes[a] in a Typical Text

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Alfred Hitchcock

In 1944, he concocted the ideas of a film--Notorious--based on Nazis working in Brazil on a super-bomb. He went to physicist Robert Millikan and asked whether such a weapon was possible. (5) Millikan, who was working on the U.S. atom-bomb project under strictest secrecy, turned white (3) and spent two hours persuading (8) Hitchcock that such a theory was impossible. It was not until Hiroshima that Hitchcock understood why (6) he was being watched by the FBI.

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[a]The key for the secondary task probes appearing in parentheses in the text above:

(5): Reinstatement Cycle

(3): Control Cycle

(8): Dummy Probe

(6): Dummy Probe

Table 2

Mean Reaction Times (Msec) to Secondary Task Probes

	Type of Comprehension Cycle		
Reading Ability	Reinstatement	Control	Performance Decrement
Good	857	627	230
Poor	827	691	136

	Type of Comprehension Cycle		
Reading Ability	Inference	Control	Performance Decrement
Good	943	878	65
Poor	810	727	83

Table 3

Mean Reading Times (z-scores) by Type of Comprehension Cycle

Comprehension Cycle	Texts Requiring a Reinstatement	Texts Requiring an Inference
Sentence Wrap-up	0.38	0.39
Inference	---	0.31
Reinstatement	0.81	---
Idea Wrap-up	0.04	0.01
Control	-.014	-0.12